

DOI: <https://doi.org/10.34069/AI/2023.66.06.27>

How to Cite:

Sagan, O.V., Blakh, V.S., Perminova, L.A., Mironenko, O.V., & Yakovleva, S.D. (2023). Formation of informational and digital competence of the student of primary education by means of robotics. *Amazonia Investiga*, 12(66), 295-303. <https://doi.org/10.34069/AI/2023.66.06.27>

## Formation of informational and digital competence of the student of primary education by means of robotics

### Формування інформаційно-цифрової компетентності здобувача початкової освіти засобами робототехніки

Received: May 23, 2023

Accepted: June 29, 2023

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#### Abstract


The article examines the problem of forming the information and digital competence of elementary school students by means of robotics. Our research work is aimed at analyzing the modern state of educational robotics, the readiness of educators for its teaching and experimental testing the possibilities of robotics as a means of forming information and digital competence of primary education seekers. The organization of pedagogical experiment meant diagnosis and correction of such components of information and digital competence as motivational, cognitive, active, reflexive, the formation of which took place in the course of pupils' learning robotics constructors and interactive manuals devoted to the history and development of robots. To measure the level of information and digital competence of primary school pupils the system of expert assessments of its components was used. As a result of observing behavior, accuracy, speed and independence during the fulfillment of special tasks connected with the search and processing of information, computational thinking, work on the Internet, understanding the ethics of working with

#### Анотація


У роботі досліджується проблема формування інформаційно-цифрової компетентності здобувача початкової освіти засобами робототехніки. Мета полягає в аналізі сучасного стану освітньої робототехніки, готовності вчителів до її викладання та в експериментальній перевірці можливостей робототехніки як засобу формування інформаційно-цифрової компетентності здобувачів початкової освіти. Організація педагогічного експерименту передбачала діагностику і корекцію таких компонентів інформаційно-цифрової компетентності як мотиваційний, пізнавальний, ціннісний, діяльнісний, рефлексивний, формування яких відбувалося у процесі опанування учнями конструкторів з робототехніки та інтерактивного посібника, присвяченого історії та розвитку роботів. У результаті спостереження за поведінкою, точністю, швидкістю та самостійністю під час виконання спеціальних завдань, пов'язаних з пошуком та обробкою інформації, обчислювальним мисленням, роботою в Інтернеті, розумінням етики роботи з інформацією, тощо рівень

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information etc. the level of information and digital competence of every pupil is defined as the sum of all its indexes. The generalization of the results allowed the conclusions: the use of robotics constructors and interactive manuals, online resources that imitate actions with robots help to increase the level of information and digital competence of education seekers.

**Keywords:** computational thinking; informational and digital competence; robotics; student of primary education.

## Introduction

Analysis of the level of development of the education system in Ukraine shows that the priority is to improve the current quality, which is the basis for the formation of an educated creative personality. The organization of the educational process, which is based on the competence approach, has a significant influence. The implementation of this approach in education has a significant history and certain features that are related to the specifics and stages of educational systems development. These stages can be distinguished as 60-70s in the United States and 70-80s of the twentieth century in Western Europe, when they began to apply the competency model of learning. This model is considered in the context of activity education, the purpose of which is to train professionals who are able to compete in the labor market and have high-level professional competencies.

In the concept of the New Ukrainian School, 10 key competencies are singled out, which are end-to-end and are formed through the content and means of all educational components. In our research, we focus on the formation of information and digital competence in students of primary education, the feature of which is rapid transformation. Since digital technologies are developing extremely quickly, this requires a review and modernization of the content of information technology education, which means the search for innovative means and methods of learning.

In previous studies, we considered aspects of the functioning of the modern digital educational environment, its structural elements, in particular technologies: adaptive learning, big data, neurotechnology and artificial intelligence, components of robotics, virtual and augmented reality, the Internet of Things, etc. (Sagan, Blakh,

інформаційно-цифрової компетентності кожного учня визначається як сума всіх її показників. Узагальнення отриманих результатів дозволило зробити висновки про те, що використання конструкторів з робототехніки, інтерактивного посібника, онлайн засобів, які імітують дії з роботами, сприяють підвищенню рівня сформованості інформаційно-цифрової компетентності здобувачів освіти.

**Ключові слова:** інформаційно-цифрова компетентність; здобувач початкової освіти; робототехніка; обчислювальне мислення.

Los, Liba & Kazannikova, 2022; Sagan, Nahrybelniy, Nahrybelna, Fediaieva, Liba & Kabelnikova, 2020).

Within the framework of this article, we update the involvement of robotics in the educational process, which every day attracts more and more attention of scientists, teachers, parents, as a valuable tool for the development of students' cognitive and social skills, as well as as a support for the study of natural sciences, mathematics, language and technologies.

**The purpose** of the research is to analyze the current state of educational robotics, the readiness of teachers for its preparation, and experimentally test the capabilities of robotics as a means of forming the information and digital competence of elementary school students.

## Theoretical Framework

One of the psychological conditions for the formation of digital competence is algorithmic or computational thinking, which has been studied by many scientists. Thus, it is noted that computational thinking is a new digital literacy, it is mental processes that are actualized when formulating problems and finding their solutions in a form convenient for the performer (Jawawi et al., 2022; Jamal et al., 2021; Wing, 2006). The analysis of the characteristics of this type of mental activity allowed researchers to identify the main principles on which solving tasks using computational thinking is based: abstraction, decomposition, creation of templates, algorithmization (Vasenko & Vasenko, 2020).

Using the analysis of scientific research, we can conclude that computational thinking is a system of mental methods of actions, techniques, methods and corresponding mental tactics, the

result of which is an algorithm. There are more and more publications devoted to the development of computational thinking in children of preschool and primary school age with an emphasis on the fact that the formation of computational thinking is the basis of such important skills as coding and programming (Bers, Flannery, Kazakoff, & Sullivan, 2014; Maya, Pearson, Tapia, Wherfel, & Reese, 2015; González-González, 2019; Moreno, Robles, Román, & Rodríguez, 2019).

For students of primary education in Ukraine, these skills are regulated as the results of learning computer science in primary grades. Thus, starting from the third grade, students in computer science classes master a program such as Scratch, with a gradual transition to more complex coding topics. The results of research

related to the use of visual block programming tools in elementary school testify to the improvement in students of education not only in coding skills, but also in linguistic, interpersonal, visual, and mathematical competencies (Sáez-López, Román-González & Vázquez-Cano, 2016; Bers, González-González & Armas-Torres, 2019; Sáez-López, Sevillano-García & Vazquez-Cano, 2019).

The "hour of code" is gaining popularity in the world. This is the name of online educational materials, which are offered in 45 languages. The goal of this global program is to attract people of different ages, starting from preschool, to the coding of information, to the basics of programming, as a necessary modern skill (Fig. 1).

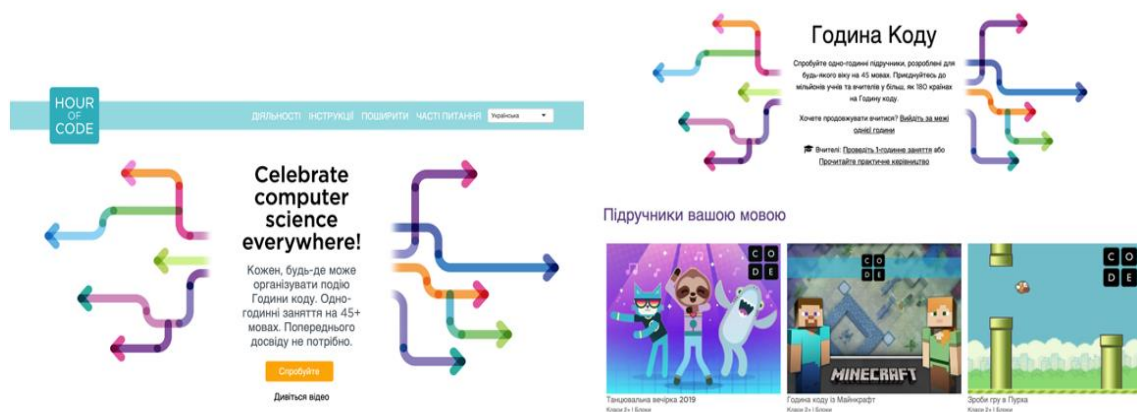


Figure 1. Screenshot of the "Hour of Code" site. Source: Hour of Code, 2023.

But the best way to visually see the results of coding is with the help of designers from robotics. Robotics, satisfying the conditions of the concept of STEM education, can be applied at any level. The use of robotics in the educational process is the subject of research by many scientists, who note that such activities, starting with the assembly, programming and testing of robots, contribute to the development of skills needed in the 21st century (Smyrnova-Trybulska & Zuziak, 2020; Kim, Kim, Yuan, Hill, Doshi & Thai, 2015; Kanbul & Uzunboylu, 2017; Valsamidis, Florou, Anastasiadou & Mandilas, 2021; Alamo et al., 2021; Sáez López et al., 2021; Caballero-González & García-Valcarcel, 2020; Turan & Aydogdu, 2020).

A general review of the literature to assess the current state of robotics as an educational technology attests to the preponderance of positive feedback and teacher testimonies in

favor of the fact that robotics has powerful opportunities for motivation, increased attention and teamwork of students (López-Belmonte, Segura-Robles, Moreno-Guerrero & Parra-González, 2021).

At the same time, surveys of teachers who teach computer science in elementary grades testify to an insufficient level of their familiarity with the basics of robotics. This is due to the fact that 75.5% of respondents have only an idea of robotics at the household level; 71.7% are familiar with the topic, but have never worked with robotics designers; 83% indicate an extremely insufficient number of relevant methodical materials.

In our opinion, the development of educational materials, manuals, methodical recommendations on robotics; appropriate training of teachers; material and technical support of the educational process allows

robotics to be considered not only as a separate topic of the program, but also as a powerful tool for forming all aspects of information and digital competence of students of primary education.

### Materials and Methods

On the basis of the educational complex, an empirical study of indicators of the formation of information and digital competence of children of primary school age was conducted. Two groups of children took part in the study, that is, 62 pupils aged 8 to 10, including 32 girls and 30 boys. Group A became experimental (n=30), group B - control (n=32).

At the first stage, empirical and theoretical material on the research problem was analyzed. The subjects were determined, diagnostic tools were analyzed and prepared. In the second stage, a declaratory diagnosis was conducted in order to determine the level of formation of the components of the students' information and digital competence. In the third stage, the robotics classes for group A had been implemented, after which a control diagnosis was conducted to determine the effectiveness of the implemented program.

The determination of the levels of formation of information and digital competence was carried out according to the criteria of T. Khilenko (2014) (Table1).

**Table 1.**

*Indicators and levels of formation of pupils' informational and digital competences*

Level	Components				
	Motivational	Cognitive	Valuable	Activity	Reflective
Low	Selfish: the presence of personal interest in information.	Factual: knowledge - recognition, naming, reproduction.	Pragmatic: information for yourself.	Information actions in educational activities: information is not transferred to other areas of information	Actions of acontrol, correction, evaluation (reflection) of an information under the
Medium	Social: information as a means of self-realization in society	Descriptive: knowledge-descriptions (analysis, comparisons, analogies, associations, interpretation)	Pragmatic: information is necessary for its approval in society.	Information actions in research activity: to solve new educational tasks, acts depending on the situation.	There are actions of a control, correction, evaluation, reflection of information with the help of the algorithm.
High	Altruistic: information for the benefit of society.	Evidential and creative: knowledge-beliefs (highlighting significant and insignificant features, establishing cause-and-effect relationships.	Unpragmatic attitude to information: for the benefit of others.	Information activities in project activities: constant participation in solving new educational tasks	Usage of the actions of a control, correction, evaluation, reflection of information independently.

Source: received by the authors

To measure the level of information and digital competence of students, a system of expert evaluations of its components was used. For this, each of the components was assigned a numerical indicator (1 point – the component is not expressed; 2 points – absent rather than formed; 3 points – formed at an average level; 4 points –

more likely to be formed than not formed; 5 points – formed).

As a result of observing the behavior, accuracy, speed and independence during special tasks related to the search and processing of information, computational thinking, work on the Internet, understanding the ethics of working

with information, etc., the level of information and digital competence of each pupil was determined as the sum of all indicators.

Thus, if the obtained indicator is in the range from 1 to 2, then a level of the formation of informational and digital competences is considered to be low; if more than 2, but less than or equal to 4 - middle; if more than 4, but less than or equal to 5 - high.

**Table 2.**

*Levels of formation of students' information and digital competence of the experimental group (%)*

Levels	Components					Formation of IDC
	motivational	cognitive	valuable	activity	reflective	
Low	20	23	40	30	47	32
Midle	47	54	47	57	47	50.4
High	33	23	13	13	6	17.6

Source: received by the authors

**Table 3.**

*Levels of formation of students' informational and digital competences of the control group(%)*

Levels	Components					Formation of IDC
	motivational	cognitive	valuable	activity	reflective	
Low	22	28	35	28	47	32
Midle	50	50	47	57	44	49.6
High	28	22	18	15	9	18.4

Source: received by the authors

Quantitative analysis of the obtained results showed that in both the control and experimental groups the studied indicators of all components have slight fluctuations (EG: 32; 50.4 and 17.6; CG: 32; 49.6 and 18.4).

To test the hypothesis of the coincidence of the characteristics of the two groups, it is advisable to use the Kramer-Welch test. The empirical value of this criterion is calculated based on information about the volumes of N and M samples x and y, sample means x and y and sample variances  $D_x$  and  $D_y$  by the formula:

$$Temp = \frac{\sqrt{M \cdot N} |\bar{x} - \bar{y}|}{\sqrt{M \cdot D_x + N \cdot D_y}} = 0,04 \leq 1,96 \quad (1)$$

Thus, the hypothesis about the coincidence of the characteristics of the experimental and control groups before the experiment was accepted at the significance level of 0.05, which indicates the possibility of using two groups in the experiment. In order to test the research hypothesis, we conducted the robotics classes in the experimental group during the first semester of the 2021-2022 academic year. At the first stage,

## Design of investigations The Results and Discussion

The purpose of the ascertainment diagnosis was to find out the level of formation of the components of information and digital competence of primary education students, the results of which are shown in Tables 2, 3.

in the form of an educational project, a search, systematization and presentation of materials on the history of robots, their purpose, current status, short-term prospects, etc. was organized. In order to popularize the outlined problem, an interactive guide about robots and their purpose was created.

Learning with the help of robotics is, as a rule, the activity of designing, creating and executing programming. Students make robots using small parts and then develop a way to create a wireframe model. The robots will be functional after students can write their own code using the software.


Robotics classes create a pleasant environment, because in addition to educational activities, the pupils have a fun. The process itself helps to use the game scenarios by jointly designing and creating robots. The use of robotic tools allowed us to observe the changes demonstrated by the students of the experimental group: improving thinking skills, including computing, which is the basis of activities on abstract problems and finding solutions that can be automated; formation of students' linguistic skills through

programming; teamwork skills that are closely related to communication skills. And the emergence of quality communication in groups affects the improvement of learning outcomes. Thus, gradually communication in the group focused on finding a strategy, choosing details, analyzing code, editing the program, and so on. At the same time, there was a change in priorities in motivational and evaluative activities: from self-pragmatic to altruistic-non-pragmatic, as the

success of a collective project depends on the ability to share information, personal achievements for the benefit of the team, etc.

We will give an example of the practical activity on topic "Insects", which helps to check out the level of a formation of the components of pupils' informational and digital competences (Table 4).

**Table 4.**  
*Stages of the diagnostic activity on topic "Insects"*

Stage	Patrs	The method of a checking of the formation
1	<p><i>Search, processing and verification of information</i></p> <p><i>Information and media literacy</i></p> <p><i>Internet Safety Skills</i></p>	<p>In front of the children is a basket of sheets. Each sheet has different facts. Children must check each fact using a mobile phone, find out whether this fact is about insects and whether it is true. Before searching, we remember the safety rules on the Internet and check how children follow them. For each correct fact, children receive a part of the instruction-algorithm for assembling a set is called "Flower".</p> 
2	<p><i>Algorithmic thinking and Basics of programming</i></p>	<p>The more correct answers, the easier it will be to complete the second (practical) part of the lesson. One part is not enough for a such work. Children need to make up the algorithm for this part of the work. Then the children are shown a sample program for the manufactured model. And they have to program their device.</p>
3	<p><i>Understanding the ethics of working with information</i></p>	<p>The last task is the presentation of the product. To do this, you need to prepare a structure, program it and find a poem about a bee on the Internet. At the same time, children's knowledge of copyright is tested.</p>

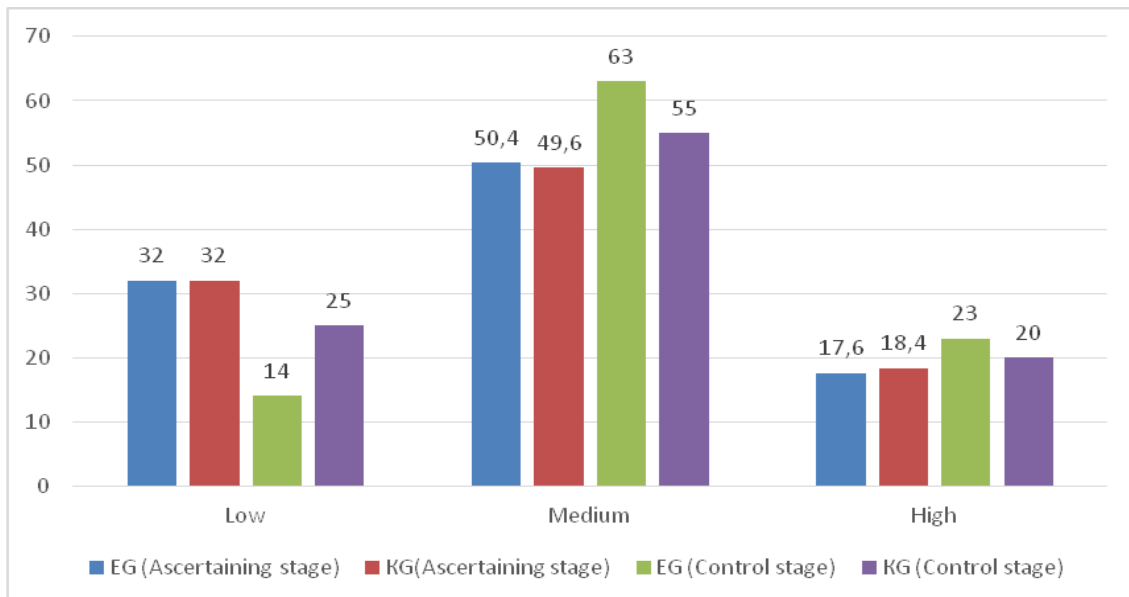
Source: received by the authors

We must note that robotics, being interdisciplinary, requires the experience in a wide range of the fields from mathematics to aesthetics, and allow to make an interest and involvement of the pupils into a work.

In February 2022, we conducted a control diagnosis of the studied competencies of participants from both groups.

Using the same diagnostic techniques used at the ascertaining stage, we investigated the dynamics of the formation of information and digital

competence of primary school students. The results are shown in Fig. 2.



**Figure 2.** Comparative analysis of the levels of pupils' informational and digital competences

**Determine the authorship of each of the figures in the article**

As can be seen from the diagram, in the experimental group we observe a positive change in the formation of information and digital competence at the medium and high levels (by 12.6% and 5.4%, respectively). Significant dynamics (18%) are noted in the reduction of the share of students who have a low level of formation of the studied competence. In the control group, we also have positive changes (5.4% at medium and 1.6% at high levels) and a 7% decrease in students with a low level of digital competence. But in a comparative aspect, the students of the experimental group have qualitatively better results.

We apply the static method to compare the characteristics of the experimental and control groups after the experiment and calculate the value of the Cramer-Welch test:

$$\text{Temp} = 2,42 > 1,96 \quad (2)$$

Thus, the probability of differences in the characteristics of the experimental and control groups after the experiment is 95%.

Since the states of the experimental and control groups coincide before the beginning of the experiment, and differ after the end of the experiment, we conclude that the positive

changes in the experimental group are due to the use of experimental teaching methods.

**Conclusions**

Information and digital competence is a dynamic personal formation, the formation of which is in the plane of transformations of motivation, cognition, activity, value-reflective skills. The rapid development of the digital industry regulates constant requirements regarding the levels of formation of this phenomenon. In view of the increased attention to artificial intelligence tools, the need for the formation of computational thinking, as the basis of such important skills as coding and programming, is actualized. These skills are organically formed in the process of educational robotics.

Analysis of the source base, questionnaires of practicing teachers allowed us to take a deeper look at this modern technology as a comprehensive tool for forming the information and digital competence of students of primary education. The work offers indicators and levels of formation of the studied phenomenon, as well as a system of expert evaluations of its components.

The results of the conducted research prove that the use of robotic tools contributes to the improvement of thinking skills, in particular computational, which is the basis of activities on abstract problems and finding solutions that can

be automated; formation of students' linguistic skills with the help of programming; teamwork skills, which, in turn, allows for the comprehensive formation of information and digital competence of education seekers.

In the conditions of distance learning, caused by the state of war, the direct construction of robots is impossible. Therefore, as tools that allow you to get an idea of the world of robots and basic coding skills, we recommend a suitable interactive guide, online games from the " Hour of Code " Website, Scratch program, etc. In addition to the mentioned tools, such a direction as virtual robotics is actively developing today, which allows you to code without a designer, only if you have a computer and access to the network. Such programs are being improved, expanding their capabilities and becoming an alternative to traditional robotics.

Thus, the organization of classes on robotics requires not only the availability of appropriate kits and constructors in educational institutions, but also the high qualification of informatics teachers and their readiness for self-education.

We see prospects for further exploration in the development of an educational and methodological complex on robotics, which will be useful to teachers who teach computer science in elementary grades or organize appropriate group work.

#### Conflict of interests

The authors declare no conflict of interest.

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